MONTHLY PROGRESS REPORT
MONTANA DOT "PERFORMANCE PREDICTION MODELS"
OCTOBER 2003

To:	**Susan Sillick, MDT, Jon Watson, MDT**
Agency:	**Fugro-BRE, Inc.**
MDT Contract No.:	**HWY-30604-DT**
Contract Period:	**June 2001-May 2006**
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Date Prepared:	**November 6, 2003**

PROJECT OVERVIEW

The overall objective of this research is to develop a design process and performance/distress prediction models that will enable the Montana Department of Transportation to use mechanistic-empirical principles for flexible pavement design. The project involves a comprehensive performance monitoring and laboratory testing program and spans over a period of five years.

CURRENT MONTH WORK ACTIVITIES AND COMPLETED TASKS

PHASE I

Task 1 – Literature Review

Objective: The purpose of the literature review was to summarize existing distress prediction models for load and non-load associated distresses and ride quality for flexible pavements. The major types of distress considered were: fatigue cracking, permanent deformation, thermal cracking, and ride quality. The primary focus was on the models incorporated in the NCHRP 1-37A Design Guide, but other models were reviewed as to their applicability to Montana materials, specifications and conditions.

Completed: As a result of the literature review, a draft memorandum was written that summarized the pavement performance models to be considered within this project. The draft memo was submitted to the Montana DOT (MDT) in October 2001.

Planned: The results of the calibration and validation of the NCHRP 1-37A Design Guide distress prediction models are still to be released, hopefully before the end of 2003. When these results become available, the team will update the draft memorandum and a final literature review report will be developed.

Task 2 – Review of MT DOT Pavement-Related Data

Under this task, the typical pavement related data specific to the State of Montana was investigated and documented. This included typical pavement structures, materials, soils, climatic conditions, traffic, key modes of distress, maintenance strategies, and pavement data collection procedures normally used on Montana roadways. The two major sources of information were the Montana DOT data and the LTPP data for experimental sites within and adjacent to Montana.

Completed: A review of the available pavement-related data specific to the State of Montana was completed and included in the Task 3 Experimental Factorial and Sampling/Testing Plan, which was submitted to the Montana DOT in October 2001.

Ongoing: Because the LTPP database is updated periodically, to insure the accuracy and keep the data current, Fugro-BRE will continue to monitor it and update any missing data on the test sections with time.

Task 3 – Establish the Experimental Factorials

Objective: The experimental factorials were established to insure a statistically sound calibration process based on a database that covers the typical combinations of pavement structure, subgrade soil type, and climate conditions specific for Montana.

Completed: The Experimental Factorial was completed and submitted to Montana DOT in October 2001. The factorial consists of 93 LTPP test sections of which 40 are in the State of Montana and the remaining 53 in neighboring States and Canada. In addition, 10 supplemental sites have been established and included in the factorial. The 10 non-LTPP sites are: Condon, Deerlodge/Beckhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser and Hammond.

Task 4 – Develop Work Plan for Monitoring and Testing

Completed: A Work Plan was developed and provided to Montana DOT in October 2001. The document contains the following:

- Materials sampling plan
- Initial testing plan to document the baseline condition of each test site
- Laboratory testing plan to define the materials properties and layer thickness at each test site.
- Performance monitoring plan to document time series data within the 60-month contract period.

Planned: The long-term monitoring plan will be revised after the initial analyses of the data are complete under Tasks 6 and 7.

PHASE II

Task 5 – Presentation of Work Plan to MDT

Completed: The team presented the Work Plan to Montana DOT team on October 2, 2001.

Task 6 – Implement Work Plan – Data Collection

Objective: The monitoring and testing part of the project includes 93 LTPP test sections in Montana or surrounding states and 10 supplemental non-LTPP sites. While the monitoring and testing of the LTPP sites is managed through the LTPP program and all data of interest to the project can be retrieved from the LTPP database, the monitoring and testing of the non-LTPP sites has been managed and coordinated by Montana DOT and Fugro-BRE. Therefore, the two categories will be presented separately.

LTTP Sites

There are 93 LTPP sites included in the experimental factorial. Of these, 40 are located in Montana and 53 in the neighboring States and Canada.

Ongoing: Assessing the availability of testing and monitoring data for the LTPP sites is a tedious and time-consuming process. In addition, with each update of the LTPP database, the process has to be repeated. To minimize the time and effort allocated to this task, the research team concentrated first on the development of the calibration and validation database where all the data extracted from the LTPP database will be stored. The next step was to write a set of queries that could be used at any time in the future to extract the data needed from the LTPP database, and update the information in the calibration/validation database. At this stage the queries are written and a code is being developed that will run all queries automatically whenever an update is to be made.

Planned: When the population of the calibration/validation database is completed with LTPP data, a summary of available testing and monitoring data will be made. The areas of the database that lack sufficient data will be identified. In addition, this will make possible starting the calibration analyses for the LTPP sections.

Non-LTPP Sites

The 10 non-LTPP sites are: Condon, Deerlodge/Beckhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser, and Hammond.

Completed: A field investigation report was completed by the project team and included a summary of the distress surveys, field sampling results (cores, borings, and other geotechnical information), FWD deflections (Round 1 only), and longitudinal profiles from each of the supplemental sites. The field report was submitted to Montana DOT in August 2002.

The first round of deflection tests was backcalculated and summarized. In addition, the second round of deflection testing was backcalculated utilizing the same pavement

structure information as the Round 1 data. Comparisons of the laboratory-derived values with FWD derived values were provided in the April and May 2003 monthly reports.

Unbound materials from the 10 sites selected in the experimental factorial were tested at the Fugro-South laboratory in Houston, Texas. Moisture-density curves at modified compactive effort (AASHTO T180) were derived for each of the 17 materials prior to testing. A repeated load resilient modulus test was performed for each material at optimum moisture content and maximum dry density (modified). The results of these tests were presented in the April and May 2003 monthly reports.

Asphalt concrete cores were retrieved from the 10 sites and tested. The following tests were performed: indirect tensile (diametral) resilient modulus, indirect tensile strength, low-temperature indirect tensile strength, and low-temperature, static creep tests. All test results were presented in previous reports (March, April and May 2003) except for the data showing the low temperature indirect strength and strain at failure, which is currently being analyzed.

Cores of cement treated/stabilized bases (CTB/CSB) were tested as well. However, due to specimen size requirements, only 2 of the 7 treated base materials were tested for elastic modulus. Of the remaining 5, 4 were tested for seismic modulus, and 1 could not be tested. The results of the seismic tests were presented in the August 2003 monthly report. The modulus values obtained were highly variable with values of the coefficient of variation in most cases higher than 40 percent. Depending on the results of the calibration analyses in which these treated base moduli values are used as inputs, Fugro-BRE may ask TTI to perform diametral resilient modulus on the same samples to increase our confidence in the results of the seismic testing. Density tests have been performed on 5 of the 7 treated base materials and the results have been included in the August 2003 monthly report.

Two of the 10 non-LTPP sites, namely Deerlodge/Beckhill and Condon, contained "pulverized existing HMA and base materials," which were not sampled or tested. The layer moduli assigned to these layers in the calibration analyses are the ones backcalculated from FWD deflections.

Ongoing: The data from the low temperature indirect tensile strength for HMA cores is currently being analyzed. In addition, the results of the calibration analyses are being reviewed by the team.

Planned: Two issues need to be re-evaluated after the results of the calibration exercise on the 10 non-LTPP sites are available and have been reviewed. First, it will be decided whether more sites will be included in the testing/monitoring program. Materials are already available for 4 additional sites (Baum Road, Lothair, Vaughn and Fort Belknap), of which Lothair and Baum Road have tentatively been selected for inclusion in the testing program

A second issue to resolve is the one dealing with discrepancies between labs and test methods in the characterization of the CTB materials (also for the non-LTPP sites). If the results of the calibration exercise show that the values used for the modulus of the CTB materials greatly influence the outcome of the calibration, the team will coordinate with the TTI lab to perform diametral resilient modulus on the available CTB samples to increase our confidence in the results of the seismic testing.

Task 7 – Data Analyses and Calibration of Performance Prediction Models

Objective: The objective of this task is to demonstrate the calibration technique required to develop and maintain the various model calibration coefficients that will be used by the department both now and in the future. As discussed with the Montana DOT, four major distress types were considered in the experimental plan and thus require prediction models and calibration coefficients. These include fatigue cracking (both surface initiated and bottom initiated surface cracks), thermal cracking, rutting or permanent deformation, and ride quality.

A second deliverable of Task 7 will be the "calibration and validation database" in which all the data necessary to validate and calibrate the pavement performance models considered would be included.

Completed: The calibration technique (or the specific steps required to determine calibration coefficients) was demonstrated to Montana DOT utilizing models similar in nature to the NCHRP 1-37A Design Guide models. The project team made a presentation to the department on August 14, 2003, which included a progress report, findings, and an illustration of the calibration exercise for the Silver Spring test section.

The calibration and validation database is close to completion. The draft database schema was included in the June 2003 monthly report. However, assessing the availability of testing and monitoring data for the LTPP sites is a tedious and time-consuming process. At this stage, most of the data seems to be available for both LTPP and non-LTPP sites. Although the upload could be done manually, the team is working on the development of a "macro" which will run all necessary queries automatically to extract the data from the LTPP database and transfer it to the appropriate tables in the calibration/validation database. As mentioned in previous reports, the LTPP and the calibration/validation database are different in structure but generally contain the same data fields that are found in the LTPP database. The different structure used for the calibration database will facilitate its use for the purposes of this contract and, at the same time, avoid the problems and difficulties specific to the LTPP database. A list of all database fields and their descriptions was generated and submitted to Montana DOT as a separate zip file along with the August 2003 monthly report. The file contains the name and description of each database field and all other database properties associated with these fields.

Ongoing: The research team is working on the development of a "macro" which will run all necessary queries automatically to extract the data from the LTPP database. This macro will be very helpful in the future when new updates of the LTPP database will become available and the calibration and validation database will need to be updated.

An initial calibration exercise was performed for the 10 non-LTPP experimental sites. Material test data, together with historical traffic and climatic data, were used to predict the performance of these sites in terms of fatigue cracking and rutting in the asphalt concrete layer and rutting in the base and subgrade layers. Predicted distress was compared to results of the two distress surveys available for these sites (June 2002 and June 2003) and to the rutting measurements taken in October 2001. The results of this exercise were reported in the July-September 2003 Quarterly Report and are currently under review by the team.

New: A review of all the LTPP traffic tables has been re-initiated with the occasion of a new update of the LTPP database. The completeness of the data will be documented and the need for additional traffic information will be assessed.

Planned: A calibration analysis, similar to the one performed on the non-LTPP sites, will be performed on the LTPP experimental sites. However, this will commence after the population of the calibration validation database with LTPP data and after the review and eventual modification of the algorithm used for the 10 non-LTPP sites.

Note that the calibration analyses performed so far do not address specifically the values of the calibration coefficients, but are limited to comparisons of predicted-to-measured distress using several widely used performance models, and not necessarily the NCHRP 1-37A Design Guide models. Upon release of the NCHRP 1-37A Design Guide information, expected by the end of 2003, the team will replace the current versions of the models with the Design Guide models and then proceed to the actual calibration of model coefficients. In addition, the NCHRP 1-37A Design Guide environmental database will be used, which will include information for Montana and adjacent regions.

Task 8 – Final Report and Presentation of Results
Task not yet initiated.

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below:

- Coordinate with Montana DOT personnel on an as-needed basis.
- Finalize the analysis of low temperature indirect tensile strength test data
- Finalize review of calibration exercise for non-LTPP sites and start a similar process for the LTPP sites
- Finalize macro for data extraction and begin upload of LTPP data into the validation and calibration database; continue populating the database with the data from non-LTPP sites

PROBLEMS / RECOMMENDED SOLUTIONS

No problems were encountered during last month and none are anticipated next month.

FINANCIAL STATUS

The Financial Summary I table shows the estimated expenses incurred during the reporting period.

The Financial Summary II table provides the total project expenditures by the Montana and FHWA fiscal years in comparison to the allocated funds for each fiscal year.

The Financial Summary III chart illustrates total expenditures by month for the project.

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Financial Summary I
Estimated Expenses for Reporting Period: Fugro-BRE

Cost Element	Last Month's Cumulative Project Costs, $	Current Month's Expenditures, $	Cumulative Project Costs, $
Direct Labor	75,968	3,456	79,424
Overhead	108,634	4,942	113,576
Consultants/Subcontractors	4,050	0	4,050
ERES/ARA	21,826	561	22,388
Parsons-Brinckerhoff	12,093	0	12,093
SME	523	0	523
Dr. Matthew Witczak	0	0	0
Dr. Mark Hallenbeck	3,129	0	0
Travel	14,607	0	14,607
Testing	71,994	0	71,994
Other Direct Costs	5,800	134	5,934
Fee	31,863	909	32,772
TOTAL	350,488	10,002	360,490

Financial Summary II
Total Expenditures by Fiscal Year: Montana and FHWA

MONTANA DOT FISCAL YEAR			FHWA FISCAL YEAR		
Fiscal Year	Cumulative Allocated Funds, $	Cumulative Expenditures, $	Fiscal Year	Cumulative Allocated Funds, $	Cumulative Expenditures, $
6/1/2000-6/30/**2001**	15,000	*0	6/1/2000-9/30/**2001**	65,000	31,996
7/1/2001-6/30/**2002**	218,969	82,420	10/1/2001-9/30/**2002**	258,969	102,303
7/1/2002-6/30/**2003**	348,969	213,291	10/1/2002-9/30/**2003**	358,969	216,187
7/1/2003-6/30/**2004**	388,969	64,777	10/1/2003-9/30/**2004**	398,969	226,189
7/1/2004-6/30/**2005**	428,969	---	10/1/2004-9/30/**2005**	438,969	---
7/1/2005-6/30/**2006**	498,969	---	10/1/2005-9/30/**2006**	498,969	---
TOTAL	498,969	360,490	TOTAL	498,969	360,490

*June 2001 expenditures were combined with July 2001 expenditures.

Financial Summary III:
Total Expenditures By Month